

Estimating Incidence of HIV Infection Among Men Who Have Sex with Men, San Francisco, 2004–2014

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Abstract After 30 years of the HIV epidemic in San Francisco there is hope that the number of new infections among men who have sex with men (MSM) is decreasing and that current novel interventions such as treatment as prevention and pre-exposure prophylaxis will hasten the year that the city sees the last of new HIV infections. In addition, new HIV cases/incidence is the key indicator to measure the trajectory of the HIV epidemic. In this analysis we present an alternate age-cohort approach to estimating HIV incidence and compare our results to other indicators of incidence. Data for the present analysis were collected through National HIV Behavioral Surveillance conducted among MSM in San Francisco using time location sampling from 2004 to 2014. We estimated HIV incidence using a model where a closed population of 100 was divided into number infected and uninfected according to the HIV prevalence of the 21–25 year group and then estimated what incidence over 30 years would result in the HIV prevalence at age 50+. Incidence estimates were 7 per 1000 person years (PY) (338 cases), 7 per 1000 PY (312), 6 per 1000 PY (285) and 6 per 1000 PY (271) for 2004, 2008, 2011 and 2014, respectively. Conclusion: Our data suggest that recent declines in new HIV diagnoses among MSM in San Francisco maybe due to a reduction in a “back log” of undiagnosed cases and not as large of a decline in new cases or HIV incidence. We hypothesize that the decline in new HIV infections among MSM in San Francisco is much slower than suggested by the decline in new HIV diagnoses.

Keywords HIV · Men who have sex with men · Incidence

Introduction

After 30 years of the HIV epidemic in San Francisco there is hope that the number of new infections among men who have sex with men (MSM), which account for nearly 90 % of the local epidemic [1], is decreasing and that current novel interventions such as treatment as prevention (TASP) and pre-exposure prophylaxis (PrEP) [2, 3] will hasten the year that the city sees the last of new HIV infections. In addition, new HIV cases/incidence is the key indicator to measure the trajectory of the HIV epidemic. The San Francisco Department of Public Health (SFDPH) HIV Annual Report suggests that new diagnoses of HIV infections have declined from 517 to 279 from 2006 to 2014 [1]. In the same report, HIV incidence using the BED laboratory-based assay suggests no increases or decreases in the number of new cases in the city. Moreover, each incidence estimation method, such as using new diagnoses or laboratory based methods, has its' own biases which suggests that multiple approaches taken together could help understand the true direction in incidence. In this analysis we present an alternate age-cohort approach to estimating HIV incidence and compare our results to other indicators of incidence.

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Methods

Data for the present analysis were collected through National HIV Behavioral Surveillance (NHBS) conducted among MSM in San Francisco using time location

sampling (TLS). NHBS is the CDC-coordinated behavioral surveillance activity among key populations at risk for HIV infection in the United States [4]. Sampling of MSM occurs at randomly selected venues attended by MSM, in rounds conducted every 3 years [5]. Details of the sampling method can be found elsewhere [6].

We calculated cumulative HIV prevalence over age group for all four study years (2004, 2008, 2011 and 2014). We eliminated ages 18–20 due to small sample size and because HIV prevalence in this group varied so greatly from year to year suggesting that there were unmeasured biases. Using the most recent year of data (2014) we estimated HIV incidence using a model where a closed population of 100 was divided into number infected and uninfected according to the HIV prevalence of the 21–25 year group and then estimated what incidence over 30 years would result in the HIV prevalence at age 50+ for the same 21–15 year old group. This model is based on the approach by Hallett et al. (2008) [7]. For population size estimates of HIV-negative MSM we used estimates that were derived from a migration model currently being analyzed (Hughes, Personal Communication). The method employed by Hughes takes two previously published population size estimates at two time points for MSM in San Francisco and then using an in-migration indicator from NHBS, death data from HIV case reporting and vital statistics (to estimate rates of HIV negative MSM dying), estimates the number of MSM out-migrating from San Francisco. We then calculated the number of cases a given incidence estimate would produce in a given year. We used the published number of MSM cases diagnosed each year [1]. We also estimated the number of new HIV infections among MSM from incidence estimates from BED assay carried out by SFPDPH HIV case reporting using the same population denominators from Hughes [1].

All analyses were conducted in SAS 9.3 and Excel. All rounds of NHBS had ethical approval from the University of California, San Francisco's Committee on Human Research.

Results

Demographic Characteristics

We sampled 386, 521, 510 and 411 MSM in 2004, 2008, 2011 and 2014, respectively. In terms of race/ethnicity, the samples were over 50 % White, about a quarter Latino (ranging from 19.4 to 25.9 %, 6 % Black and ranging from 11.7 to 5.6 % Asian (Table 1). The only significant changes from 2004 to 2014 were the decrease in the proportion who were Asian (χ^2 12.3, $p = 0.006$) and the increase in the proportion who were Latino (χ^2 7.7, $p = 0.05$).

Significant changes in the age groups from 2004 to 2014 were a decrease in 18–20 year olds (3.6 to 0.2 %, χ^2 16.2, $p = 0.001$), a slight decrease in 36–40 year olds (17.4 to 11.2 %, χ^2 8.5, $p = 0.04$), a decrease in 41–45 year olds (14.2 to 10.2 %, χ^2 11.3, $p = 0.01$) and a marked increase in men ages 50 and older (11.7 to 20.7 %, χ^2 23.9, $p < 0.001$). In terms of education there was a slight decline in the proportion of men who had college degrees (41.7 to 31.1 %, χ^2 10.2, $p = 0.02$) across the four study years. The majority (88.9 to 93.2 %) of the samples were gay identified in all years while bisexually identified men varied from 8.5 to 5.6 %. Straight identified MSM made up a small proportion of each sample (0.5 to 1.0 %). HIV prevalence remained stable across the four study years at about 23.5 %.

HIV Prevalence by Age Group

In 2004, HIV prevalence among 21–25 year olds was 11 % while it rose to 23 % among the whole sample 21–50+ (Fig. 1). In 2008 HIV prevalence was 3.0 % in the 21–25 year olds rising to 21.0 % in the whole sample 21–50+. In 2008, HIV prevalence was 8.0 % among 21–25 year olds rising to 23.0 % in the whole sample 21–50+. In 2014 21–25 year olds' prevalence was 10 % which rose to 25 % among the whole sample of 21–50+ year olds. Figure 1 also fits a linear trend line for each year's trajectory. Both 2004 and 2014 have similar starting points while 2008 starts from a much lower point.

Incidence Estimation and Projected New Infections

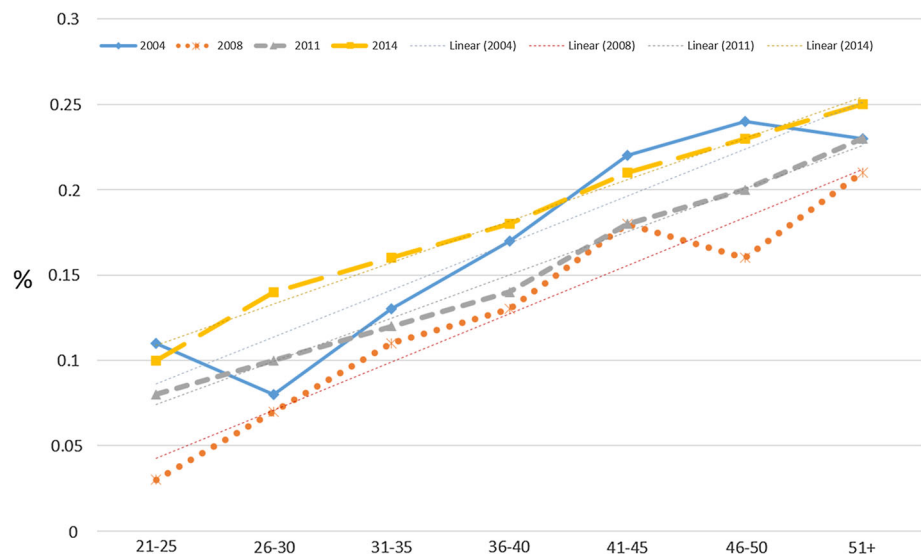
Using the prevalence trajectory for each year we modeled HIV incidence across the 30 years of age strata. That is we estimated what incidence would have to be over the age strata to arrive at the HIV prevalence in the oldest age strata. For 2004, our starting point was the linear trend from 8 % prevalence in the 21–25 year old group due to the small number of 18–20 years. To reach 25 % prevalence by age 50, incidence would be 7 per 1000 person years (PY). We estimated incidence similarly for the other three study years. Incidence estimates were 7 per 1000 PY, 7 per 1000 PY, 6 per 1000 PY and 6 per 1000 PY for 2004, 2008, 2011 and 2014, respectively (Table 2).

Using our incidence estimates and population size estimates for HIV uninfected MSM in San Francisco, accounting for in and out migration (Hughes, Personal Communication), we calculated 338, 312, 263 and 271 new HIV infections in 2004, 2008, 2011 and 2014, respectively. These projections compare to the annual reported number of new HIV diagnoses among MSM in San Francisco as:

Table 1 Demographic characteristics, men who have sex with men, San Francisco, 2004–2014

Variable	MSM 1 2004		MSM 2 2008		MSM 3 2011		MSM 4 2014		χ^2 , df, <i>p</i> value
	(n = 386)		(n = 521)		(n = 510)		(n = 411)		
	n	%	n	%	n	%	n	%	
Race/ethnicity									
Asian	45	11.7	34	6.5	37	7.3	23	5.6	12.3, 3, 0.006
Black	23	6.0	37	7.1	31	6.1	25	6.1	ns
White	219	56.7	275	52.8	300	58.8	229	55.9	ns
Latino	78	20.2	128	24.6	99	19.4	106	25.9	7.7, 3, 0.05
Other	21	5.4	47	9.0	43	8.4	26	6.3	ns
Age group (years)									
18–20	14	3.6	13	2.5	5	1.0	1	0.2	16.2, 3, 0.001
21–25	59	15.3	74	14.2	87	17.1	59	14.4	ns
26–30	63	16.3	96	18.4	74	14.5	73	17.8	ns
30–35	59	15.3	71	13.6	70	13.7	63	15.3	ns
36–40	67	17.4	68	13.1	59	11.6	46	11.2	8.5, 3, 0.04
41–45	55	14.2	90	17.3	61	12.0	42	10.2	11.3, 3, 0.01
46–50	24	6.2	46	8.8	52	10.2	42	10.2	ns
50+	45	11.7	63	12.1	102	20.0	85	20.7	23.9, 3, <0.001
Education completed									
Post graduate	64	16.6	89	17.1	110	21.6	91	22.1	ns
College graduate	161	41.7	179	34.4	179	35.1	128	31.1	10.2, 3, 0.02
Some college	108	28.0	175	33.6	145	28.4	131	31.9	ns
High school or less	53	13.7	78	15.0	76	14.9	61	14.8	ns
Sexual identity									
Straight	2	0.5	5	1.0	3	0.6	4	1.0	ns
Bisexual	33	8.5	57	10.9	45	8.8	24	5.6	ns
Gay	343	88.9	459	88.1	457	89.6	382	93.2	ns
HIV infected	93	24.0	119	23.0	117	23.0	100	24.3	ns

Fig. 1 Cumulative HIV prevalence across age groups, MSM, San Francisco, 2004–2014



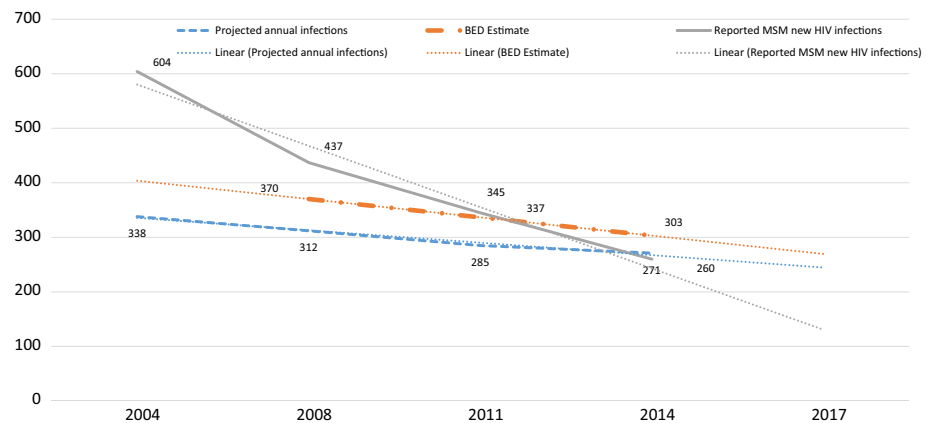
604, 437, 345 and 260 in 2004, 2008, 2011 and 2014, respectively [1]. We also show estimated number of cases based on BED estimation carried out by SFDPH HIV Case

Reporting. These were 370 in 2008 and 337 and 303 in 2011 and 2014, respectively. These three indicators, and projections through 2017, are also shown in Fig. 2.

Table 2 HIV incidence estimates, HIV prevalence and projections of new HIV infections by year, MSM, San Francisco, 2004–2014

	2004	2008	2011	2014
Prevalence at				
21 years old	0.08	0.03	0.06	0.10
50 years old	0.25	0.21	0.23	0.25
Incidence estimate, per year (i)	0.007	0.007	0.006	0.006
HIV uninfected population size (p)	48,302	44,555	43,894	45,246
Projected annual infections (p × i)	338	312	263	271
Reported MSM new HIV infections	604	437	345	240

Fig. 2 Comparison of projected annual HIV infections, BED estimate infections and reported new HIV infections among men who have sex with men, San Francisco, 2004–2014



Discussion

Our data suggest that recent declines in new HIV diagnoses among MSM in San Francisco maybe not be a true large decline in new cases or HIV incidence but due to a reduction in a “back log” of undiagnosed cases. That is new infections in the past are only showing up in case reporting recently. This is plausible when taking into account the increase efforts to expand HIV testing and an increasingly small proportion of infected MSM who are unaware of their infection. Our analysis also suggests that incidence has remained at a low but steady or only slightly declining rate for the last 10 years. While our findings do not suggest an incidence rate as high as suggested in the literature for MSM in the United States we do agree that efforts to reduce new infections among MSM could in fact be “running in place” [8].

Our analysis has limitations. Our model of HIV incidence used a simplified closed population approach. In and out migration could have dramatic effects on incidence estimates each year (i.e., if the denominator of HIV-negatives increases or decreases there is a commensurate and opposite change in incidence estimates). Nonetheless, we accounted for some of the in and out migration of HIV-negatives by using population size estimates derived from a migration based model which should ameliorate this effect. Secondly, the sample in 2014 had a higher proportion of

older MSM which could result in a higher 50+ HIV prevalence and thus over estimate incidence. However, the data from the previous three MSM cycles suggest similar incidence estimates to 2014. Thirdly, we did not calculate statistical measures of uncertainty however we did conduct a sensitivity analysis by doubling or halving the starting value in the model. This produced the same incidence estimates for each year. Lastly, our findings may not be generalizable to other cities in the United States, particularly in those locations where new HIV infections are concentrated among Black MSM. However, application of our estimation approach elsewhere may compliment efforts to understand trends in incidence in those locations.

We hypothesize that there is a decline in new HIV infections among MSM in San Francisco but a much slower one than suggested by the decline in new HIV diagnoses. Moreover, our results point out that using new HIV diagnoses may not be the best proxy for incidence. Our analysis suggests that the number of new HIV infections among MSM in San Francisco may continue to hover around 200 cases per year for the foreseeable future and begs the question “What other interventions are needed to reduce new infections to zero?”. The hypothesis can be tested in the MSM 5 round of data to be collected in 2017.

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Compliance with Ethical Standards

Conflict of Interest No conflicts of interest declared.

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